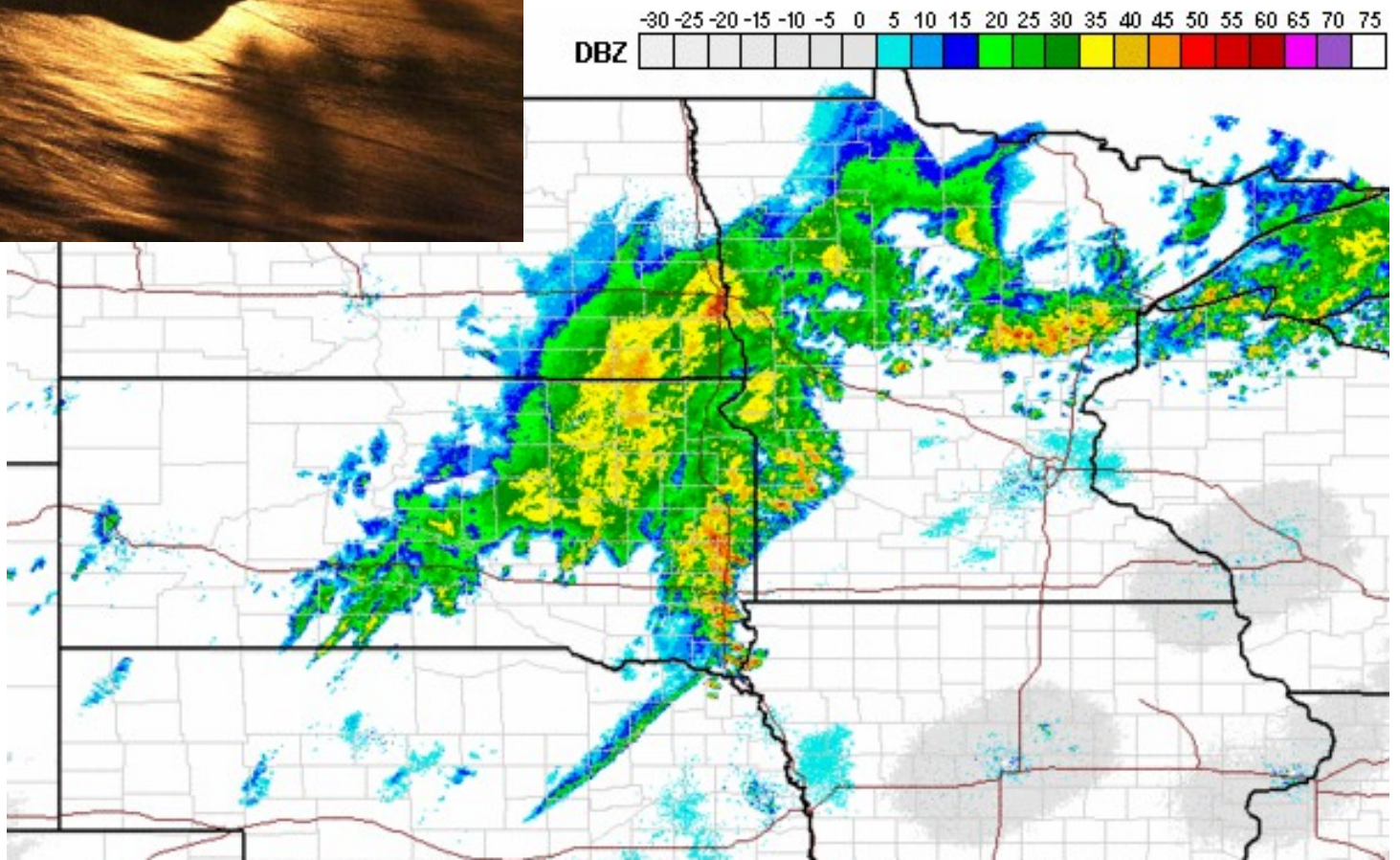
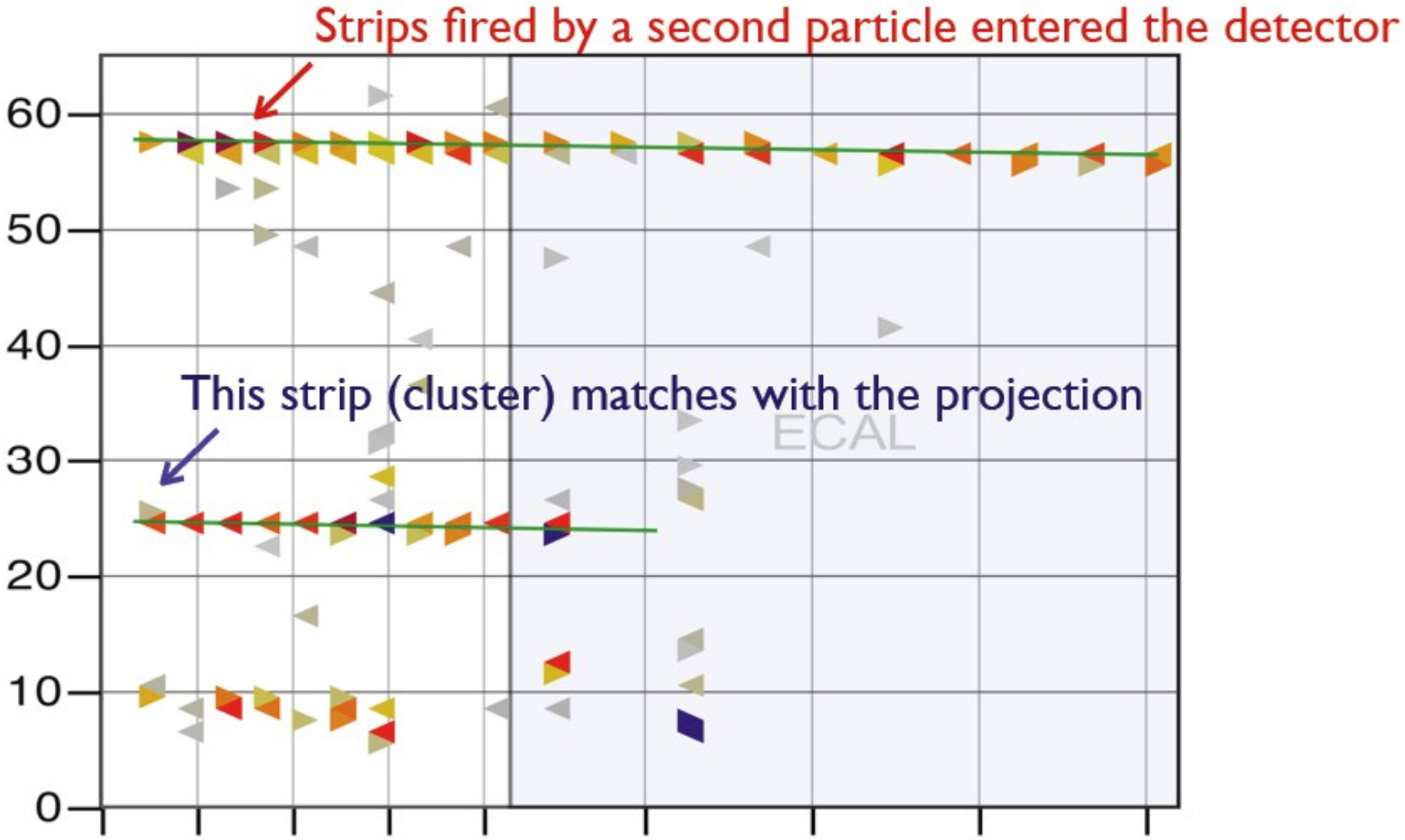
Test Beam Summary

Forecast for Duluth: cooler and drier

10 inches of rain at my house.
(This photo is not my house and my car wasn't that new)

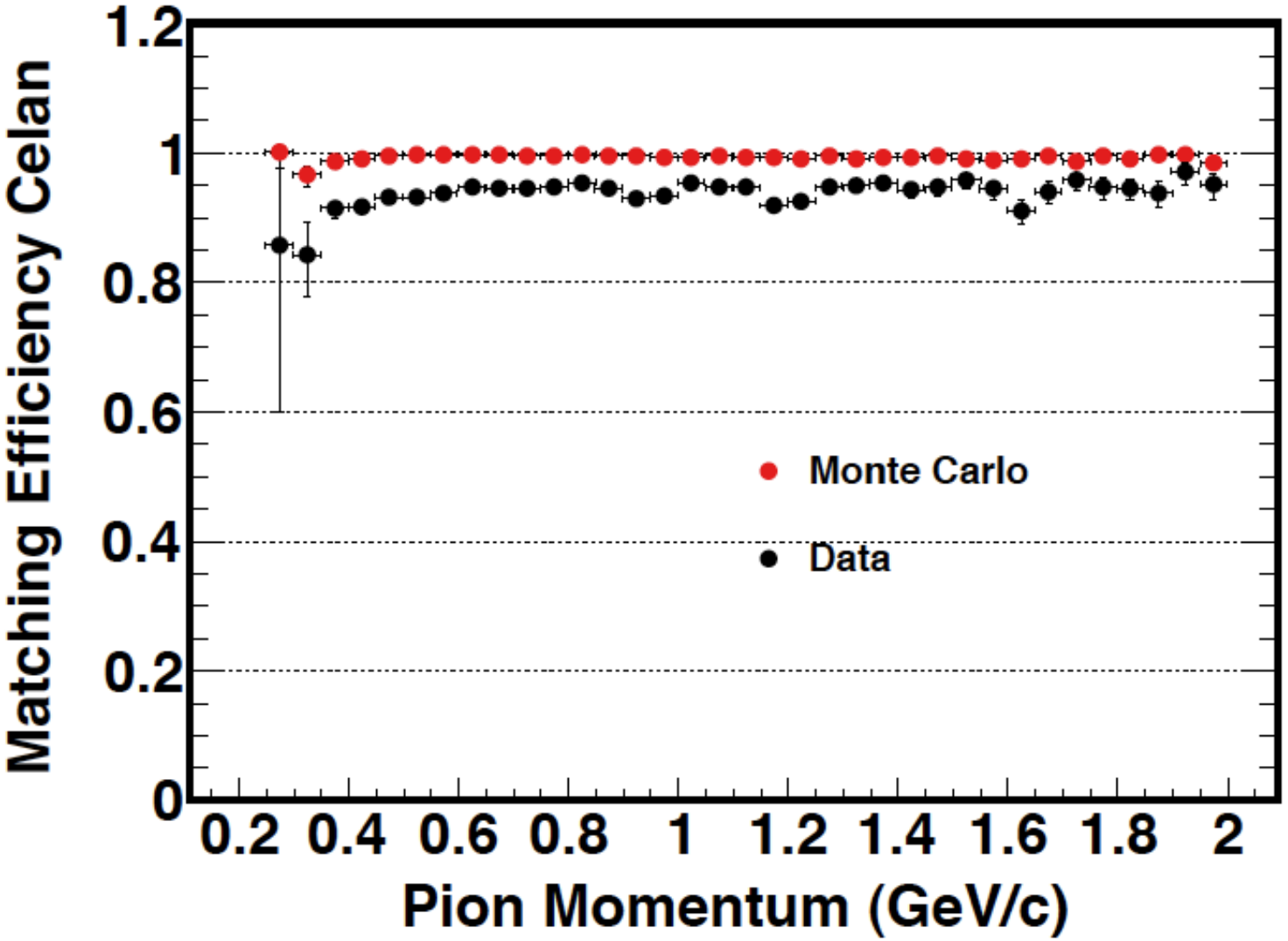


Technical progress: TBCleanEventTool



In testbeam, this often enough happens in one slice
This is the preselection that matters the most for us

TBCleanEventTool efficiency from MC study



The MC starts particles from WC4, so there is a natural interaction + decay inefficiency.

Plan: start MC at WC3, separately evaluate purity

Technical progress: other updates planned

Fix an oddity that shows up in attenuation profiles

See if MEU factors can be derived from cosmics (along with 16 GeV and 32 GeV beam muons)

Another small oddity shows up when trying to take out a few mm level global detector offsets

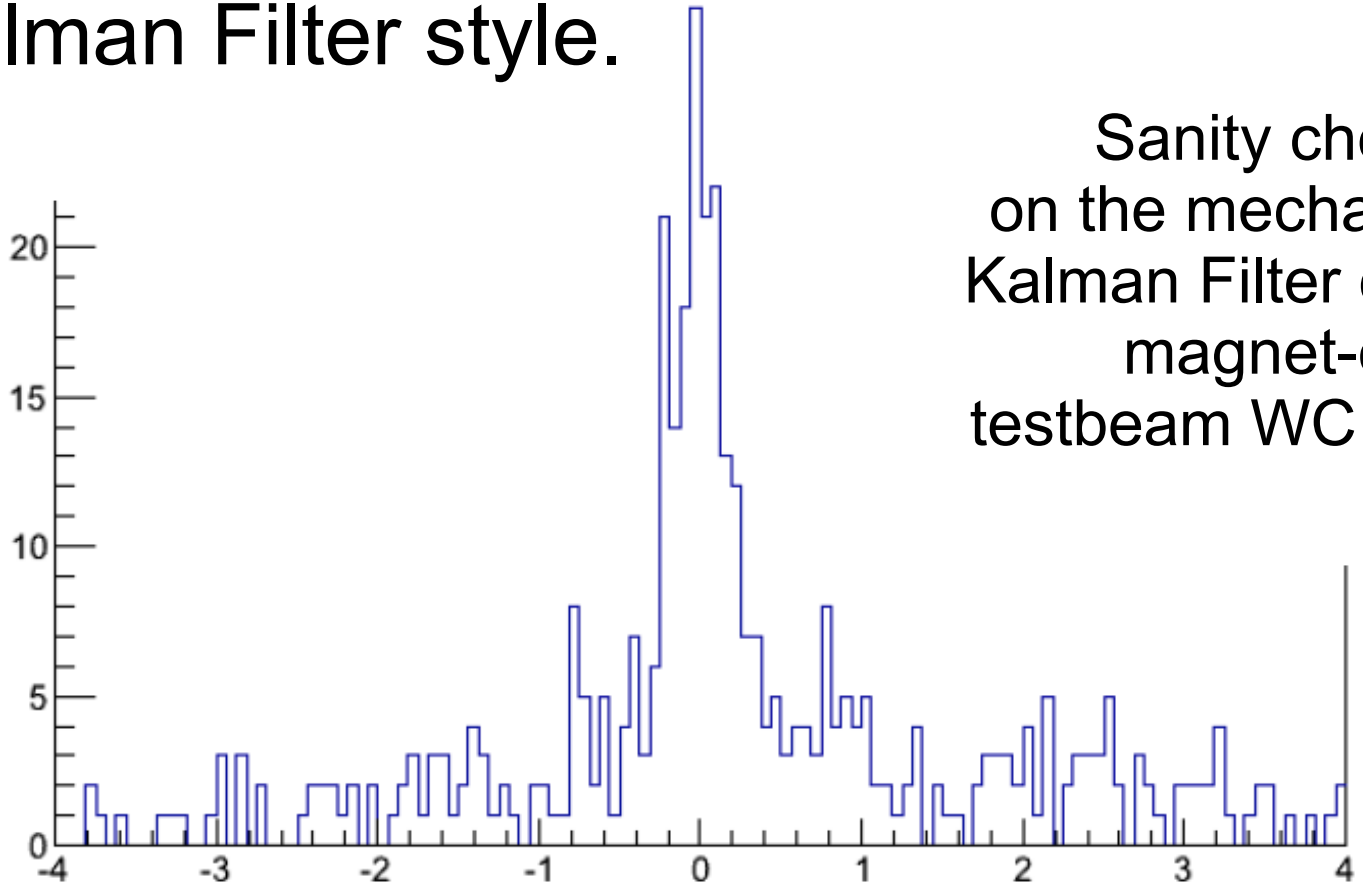
Start data-driven MC just upstream of WC3 instead of WC4 (more air + material + decay length)

Technical progress: Kalman filtering in beamline

Will Bergen, W&M

Old multiple scattering estimates: check out fine.

Will is incorporating that into the beamline fitting in the Kalman Filter style.



Sanity check on the mechanics of Kalman Filter code on magnet-off testbeam WC sample

Technical progress:
validate a calculated B-field

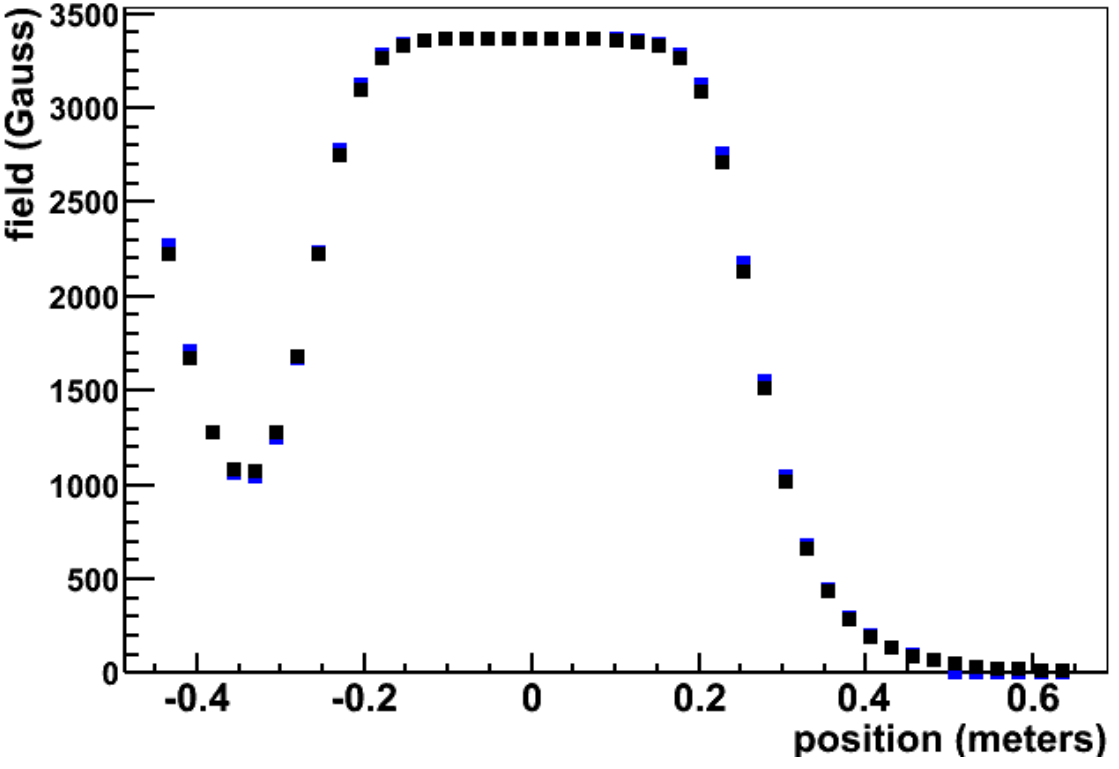
Bob Wands got information from me and Josh
and technical drawings
and used FEA software to calculate B-field

I've been comparing with data.

Comparison is dominated by the lack of
good alignment survey for the data
xyz offsets, small-scale and large-scale rotations.

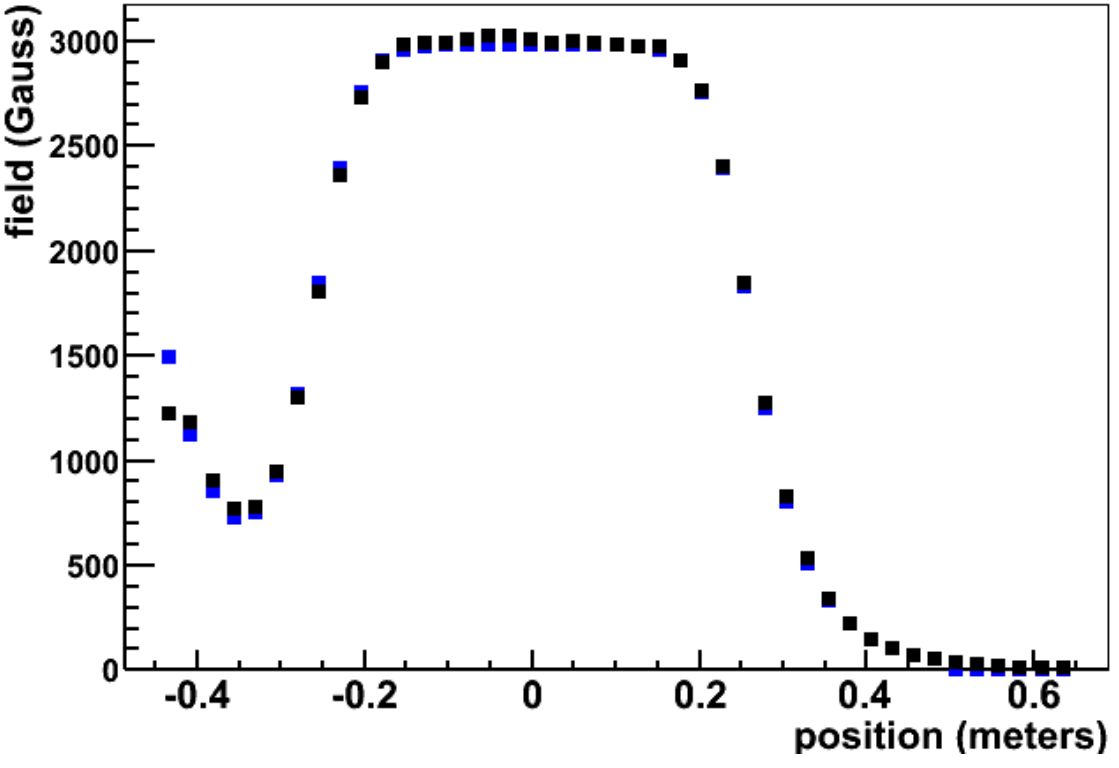
Given reasonable <1cm shifts in alignment
does the calculation reproduce the data? Yes.

Principal (vertical) Component
Black = data
Blue = calculation



Vertical Center
Horizontal Center

Vertical Center
Horizontal Edge

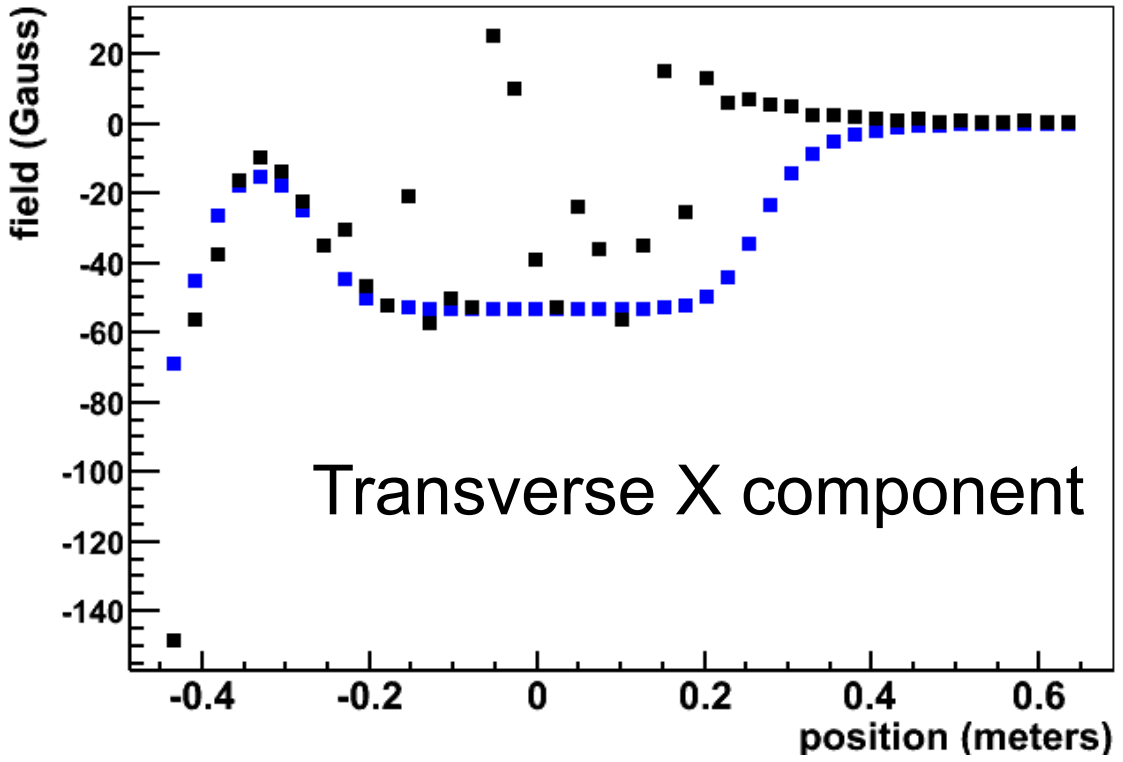


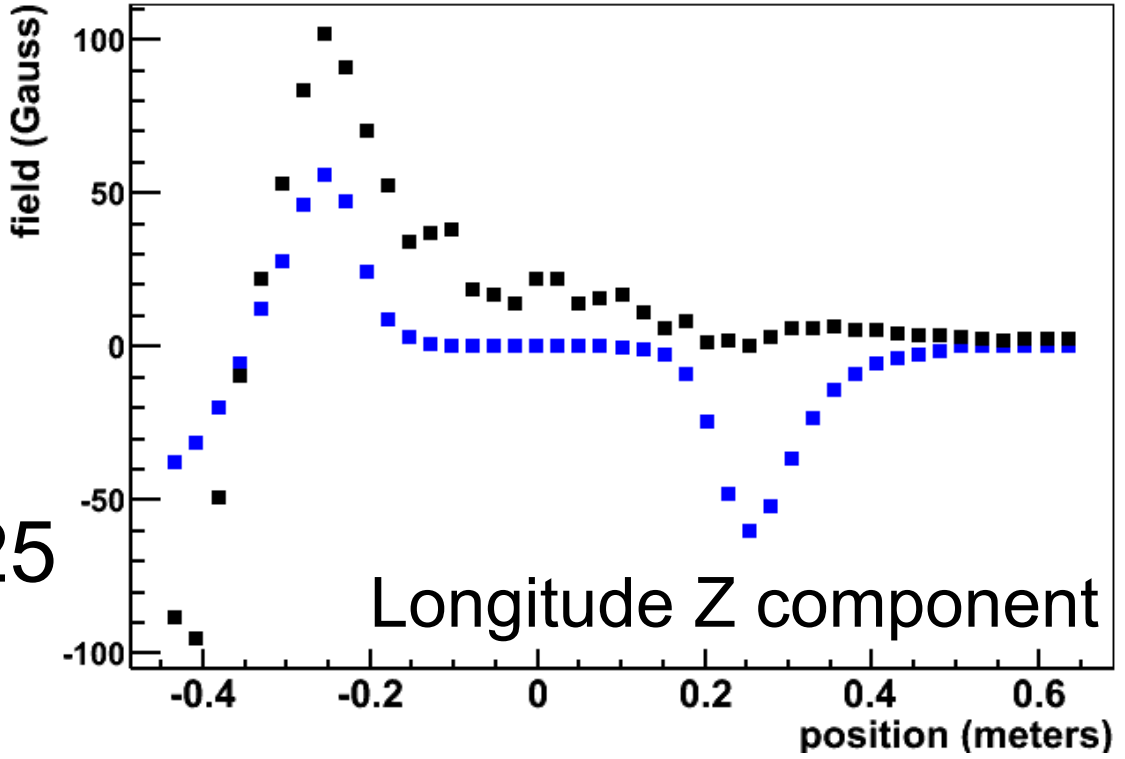
Notice, if I shifted the data coordinate system toward horizontal center just a few mm agreement at peak would improve

non-principal components
vert. center
horiz. edge
Black = data
Blue = calculation

Field is much smaller
Data quality is more affected by fluctuations
probe rotations and small shifts.

Discrepancy in Z at 0.25 consistent with tilt





B-field final steps

These look very good.
I have a full field map from Bob Wands
About to replace data-driven map with that.

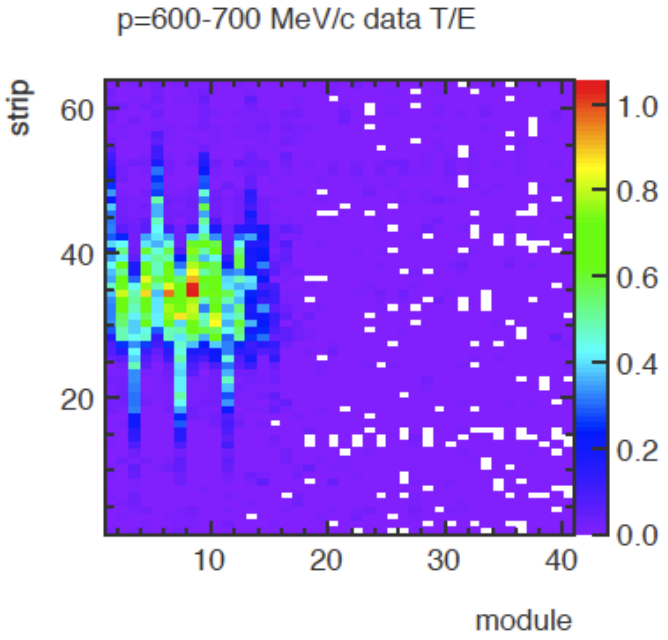
Expect basic Bdl to be different at the level of
the 1% systematic errors reported for May
but details of field structure should be better

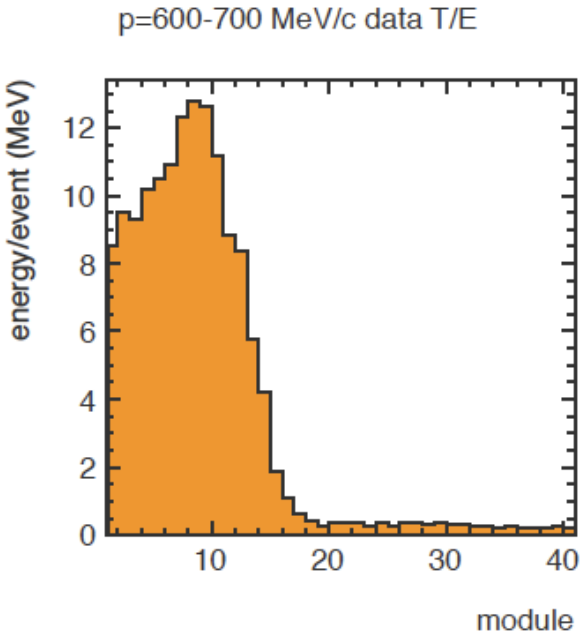
Some pieces of the systematics
should turn out better

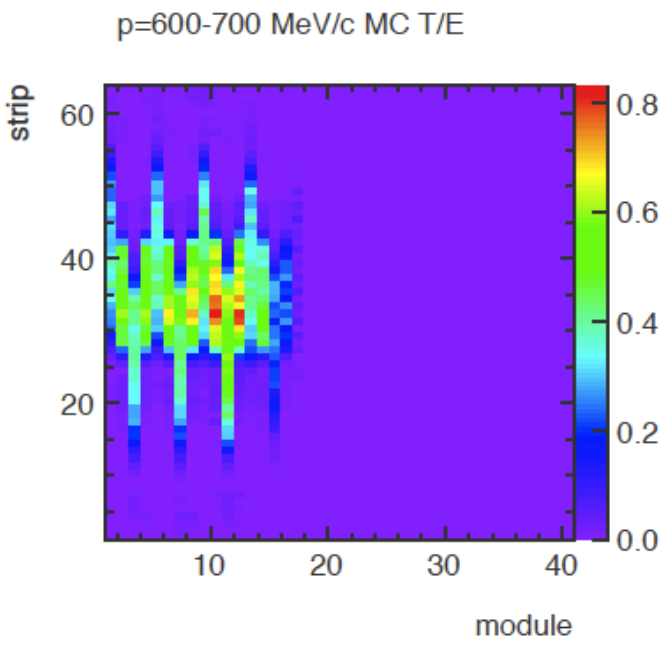
Effects of non-principal components
can be studied beyond our old B.O.E estimates

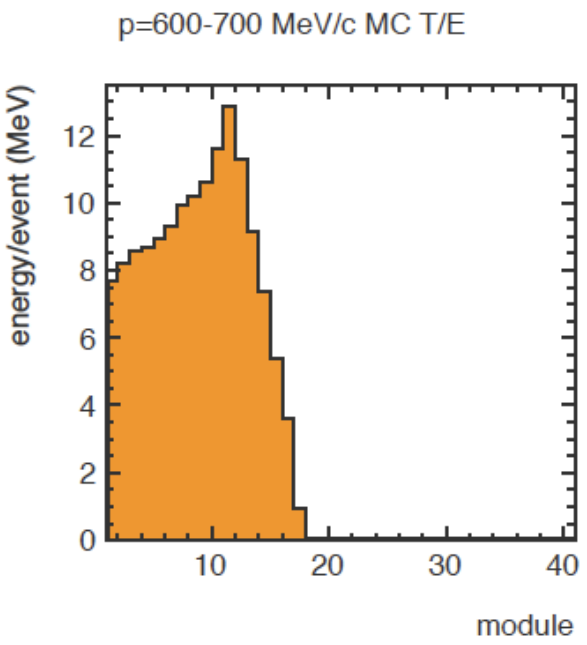
Analysis progress

Analysis progress: bias in beam momentum?









Stopping protons go further in MC than in data roughly corresponds to 10% higher E response for MC protons.

Hmm.

Analysis progress: bias in beam momentum?

If beamline momentum is off, it implies
~5% to ~10% scale bias (beam reco is high)
or 50 MeV offset, or a combination
from B-field or upstream material.

We think things are constrained better than this
to <= 2% scale bias or <5 MeV offsets
but we have a list of details to revisit.

n.b. no stopping pions, no direct comparison
but other ways this hypothesis would show up
in pion samples don't clearly show up that way.
Hmm.

Pi+ calorimetry and Geant4 model testing

Truth information digested from TG4Trajectories now available for use in testbeam analysis.

Three ways to use Geant4 truth information

1. Swap in different low energy model (one other choice)

2. Look at energy flow characteristics
pi+ goes to protons, neutrons, pizeros, neutrinos

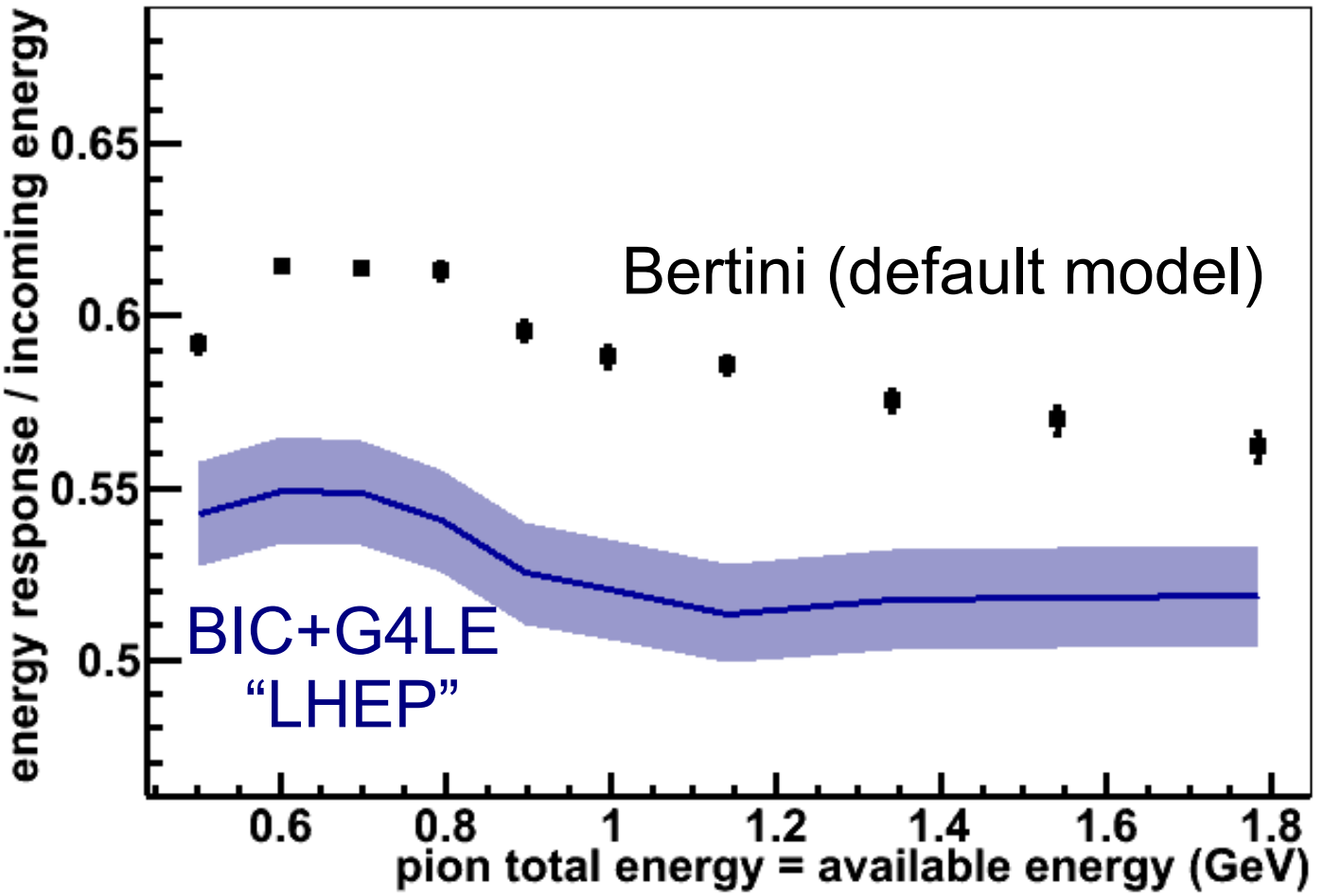
3. Where did the first interaction happen
what came out (absorption, CEX, multi-pi, decay)

Energy flow in 750 MeV Pi+ MC truth

Follow TG4Trajectories and the energy into all the possible different exclusive forms, some calorimetrically invisible
Showing fraction of total incident pion energy

	Bertini	LE+BIC	Interpretation
Primary	22.5%	22.4%	reac rate same
Proton	24.9	12.5	upcoming slide
Neutron	6.5	7.1	
Binding	17.9	16.5	
Pizero	8.9	17.1	upcoming slide
Pi+ Pi-	8.1	5.2	less multi-pi?
Neutrino	4.4	10.5	more mu decay?
Muon	3.4	3.3	or not more mu?
Nuclei	2.2	2.0	
Electron	1.3	3.7	more mu decay?

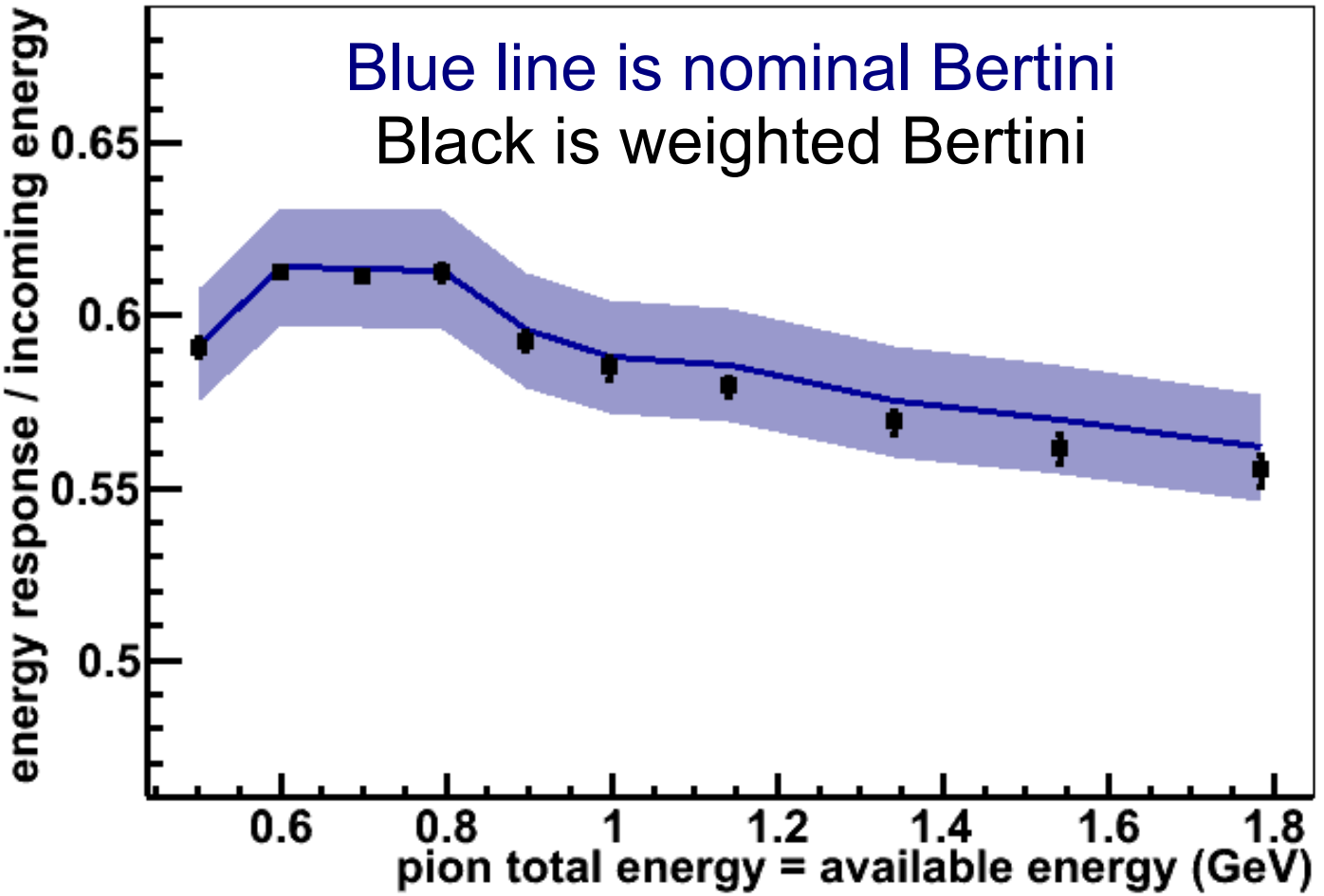
High level Pi+ energy response



Recall that data is a lot like Bertini model.
Glad we are using Bertini instead of obsolete LHEP
But this comparison is a bit of a dud, so...

“Reweight” pizero fate within Bertini model

Reweighting here actually means rejection method
Cut 30% of the events with non-zero pizero energy



Switched plotting convention blue is default!

Low E response falls a little, high E falls 1%.
Didn't change pizero energy spectrum, only rate.

“Reweight” other fates within Bertini model

Still rejection method, cut 30% events in specified category estimate shift in response, like previous slide.

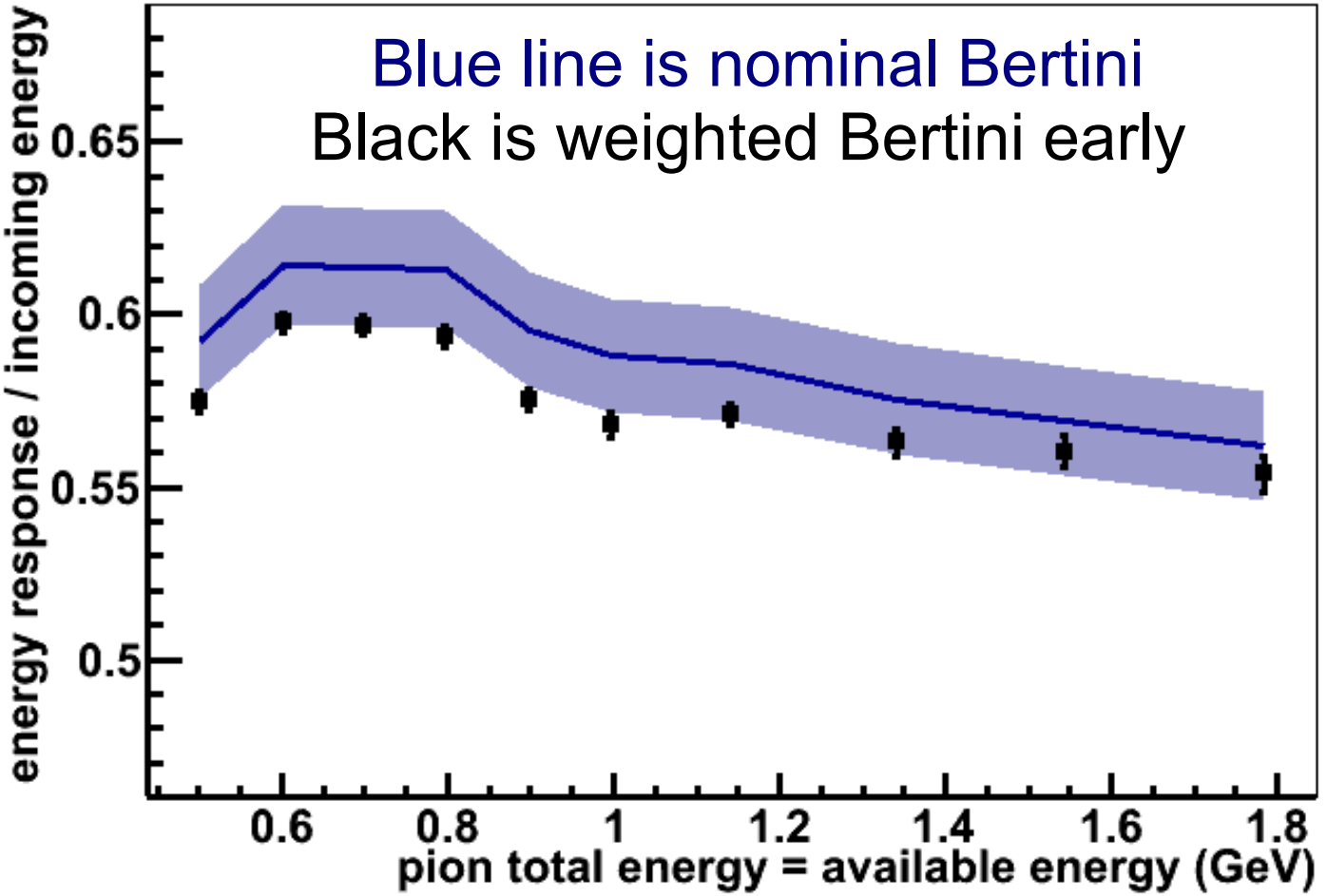
Category	LowE	HighE
Event has any pizero (prev. slide)	-0.3%	-1.0%
First interaction made pizero (18%)	-0.3%	-0.8%
First interaction had charged pi* (52%)	-0.0%	-0.5%
First interaction pion absorbed (30%)	+0.6%	+0.7%
First “interaction” had decay (7%)	-0.3%	-0.0%

Comments: these are small differences relative to good Bertini
In LHEP the decay and pizero fractions are radically different, but the outgoing energy spectra is very different.
Have not figured a good way to use truth to test for effect of outgoing pion and nucleon spectrum. Constrain in data? Hmm.

*includes soft inelastic, and multi-pion, and 7% overlap with pizero

“Reweight” truth interaction point

Rejection again, cut a linearly increasing fraction of events as the first interaction point is deeper in the detector
So resulting “early” sample effectively has higher cross sec.



I picked something by hand that wasn't unreasonable
LowE went down 3%, high E went down 2.4%

Pion reaction rate observables

A. Higuera, first look this meeting, still some issues

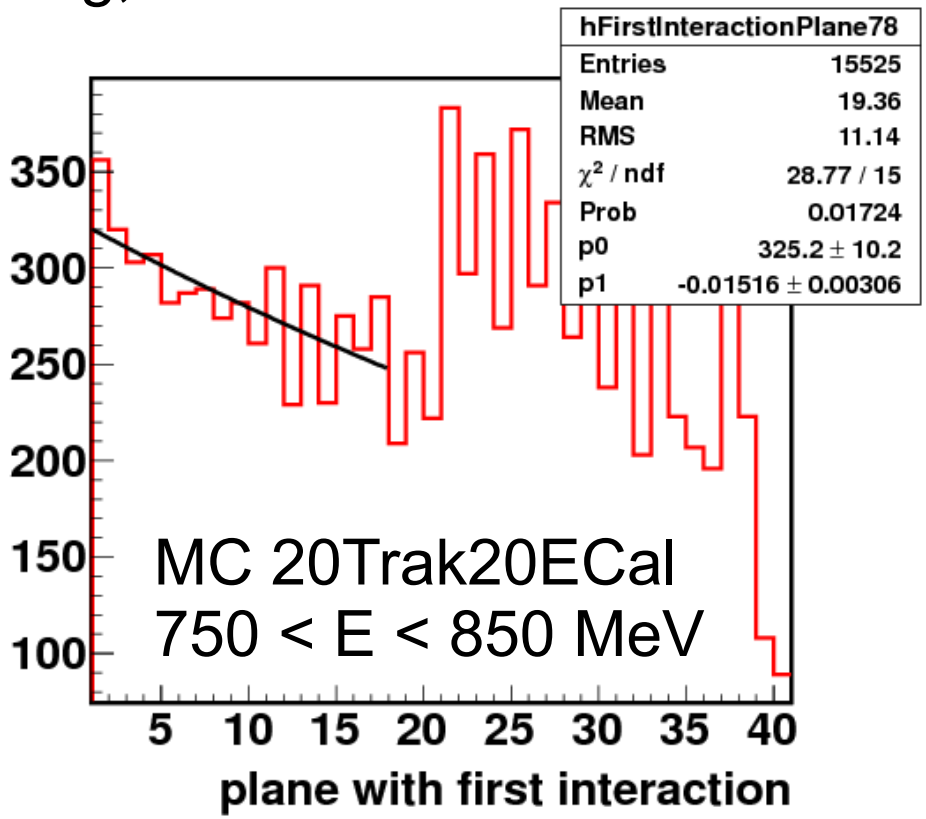
Look in widening cone along expected pion path for first instance of:

EITHER cluster > 7 MeV

OR “track” leaves cone

OR “track” ends/gaps

call it reco interaction point



The slope or exponential gives mean free path

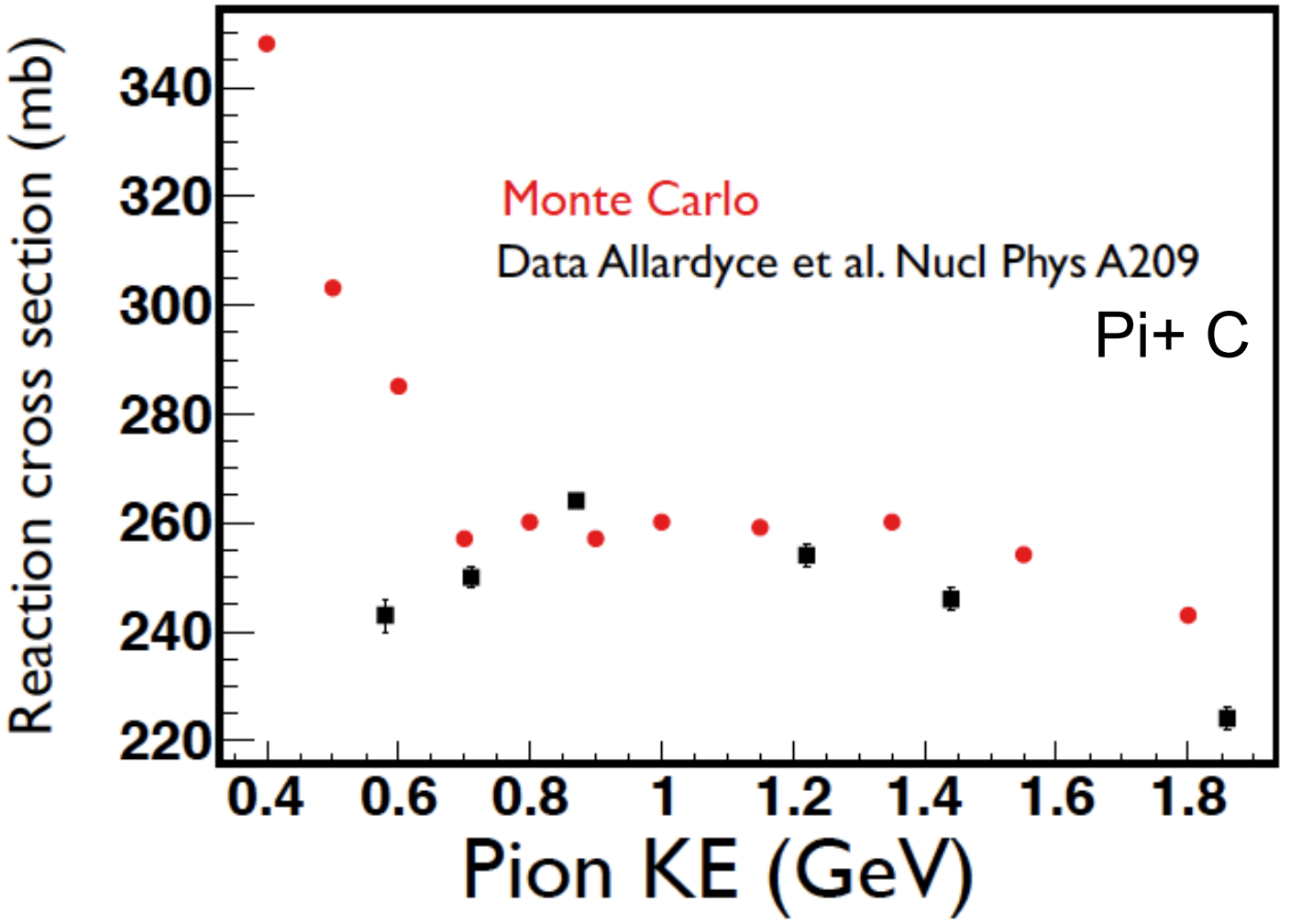
adjust for threshold effect gives reaction cross section

And in this form is a simple (too crude?) observable for making data/mc comparisons.

Switch out to tracker-based observable?

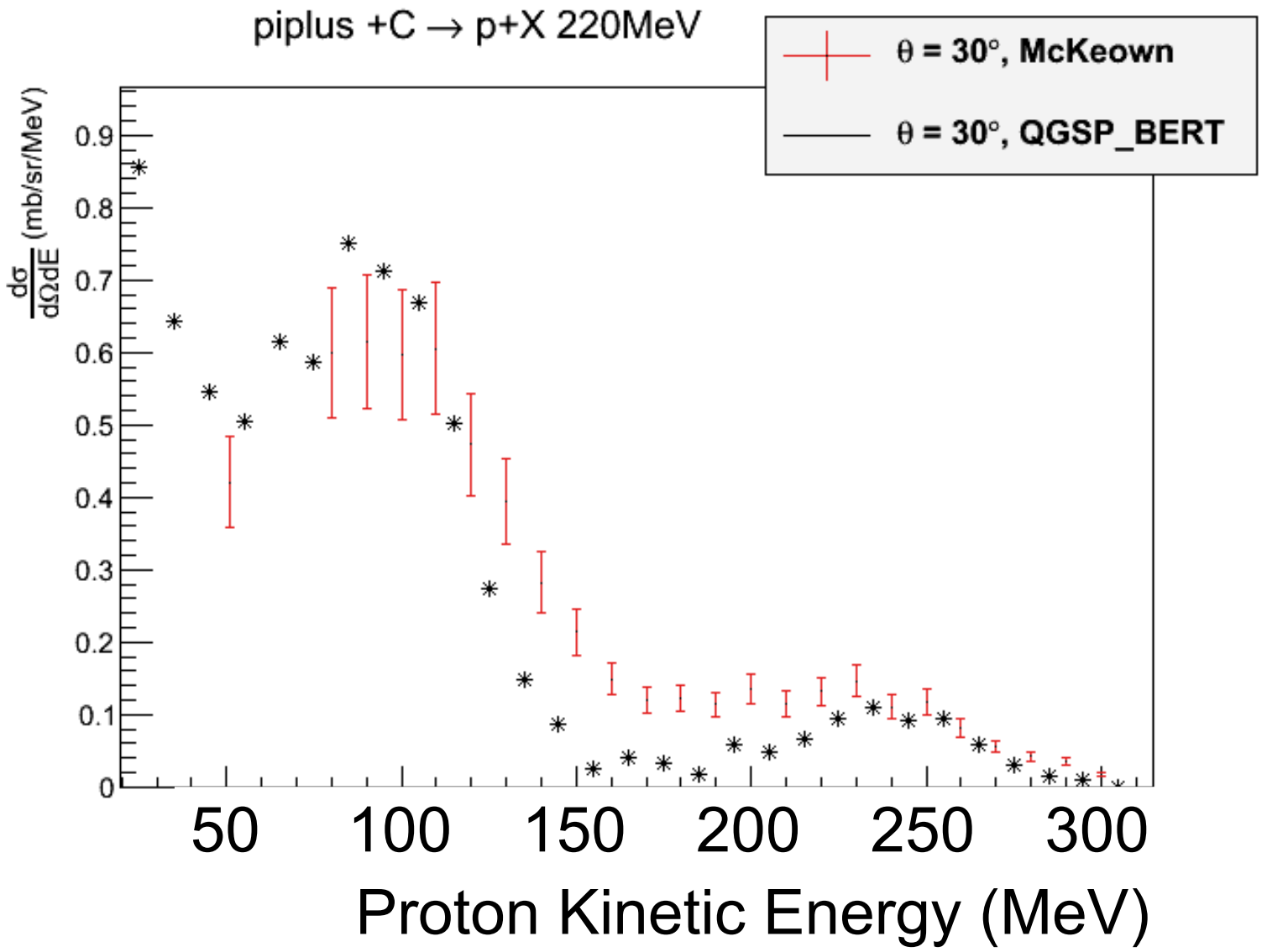
Pion reaction rate

As practice, Aaron H. built this from truth information of where G4 says the first interaction happened
He's refining how to extract this from reco quantities



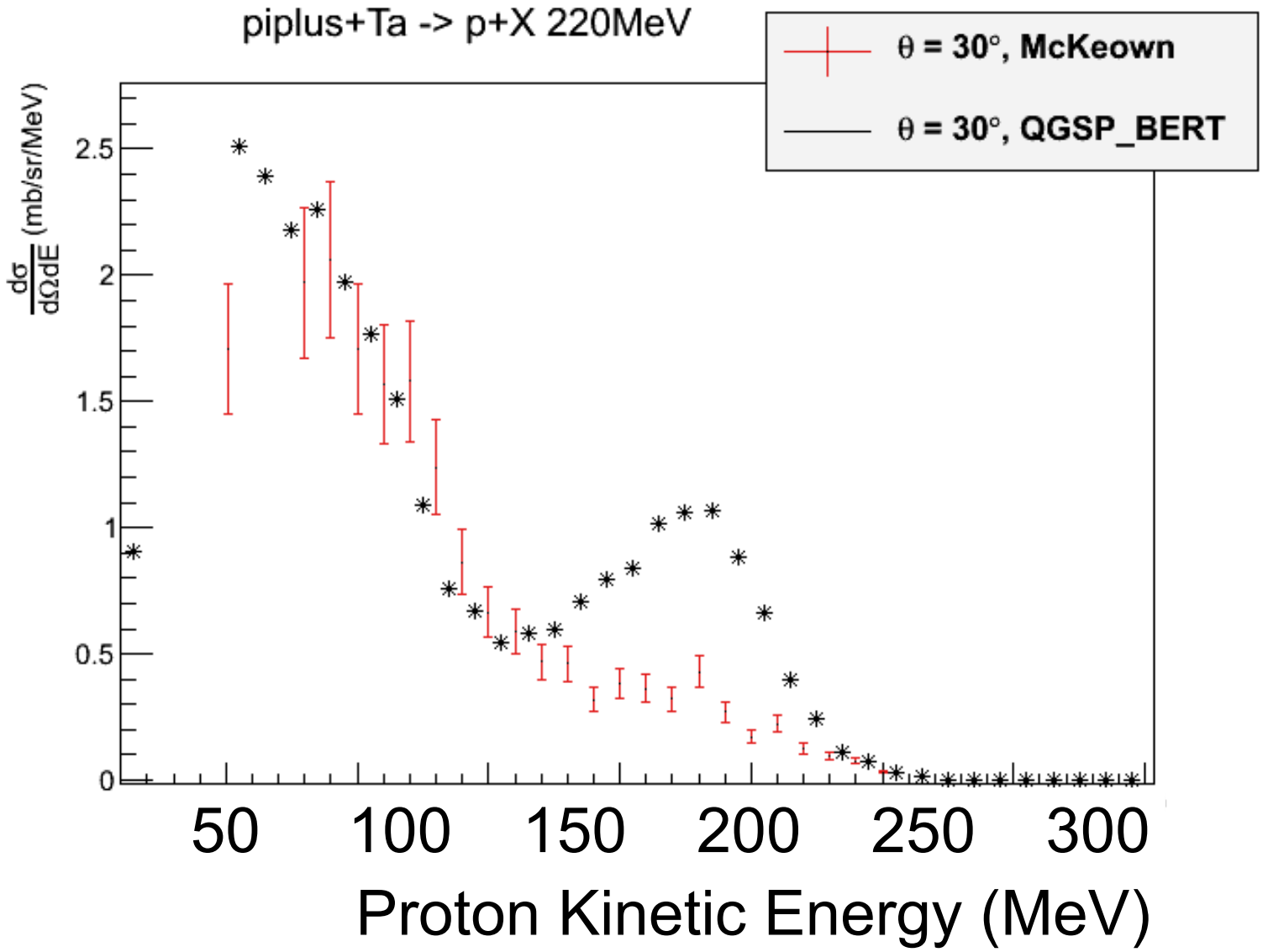
G4 to external data for proton knockout

Juan Pablo looks at the double differential cross section for knockout: 220 MeV Pi+ C → proton + X



G4 to external data, but more like our Pb

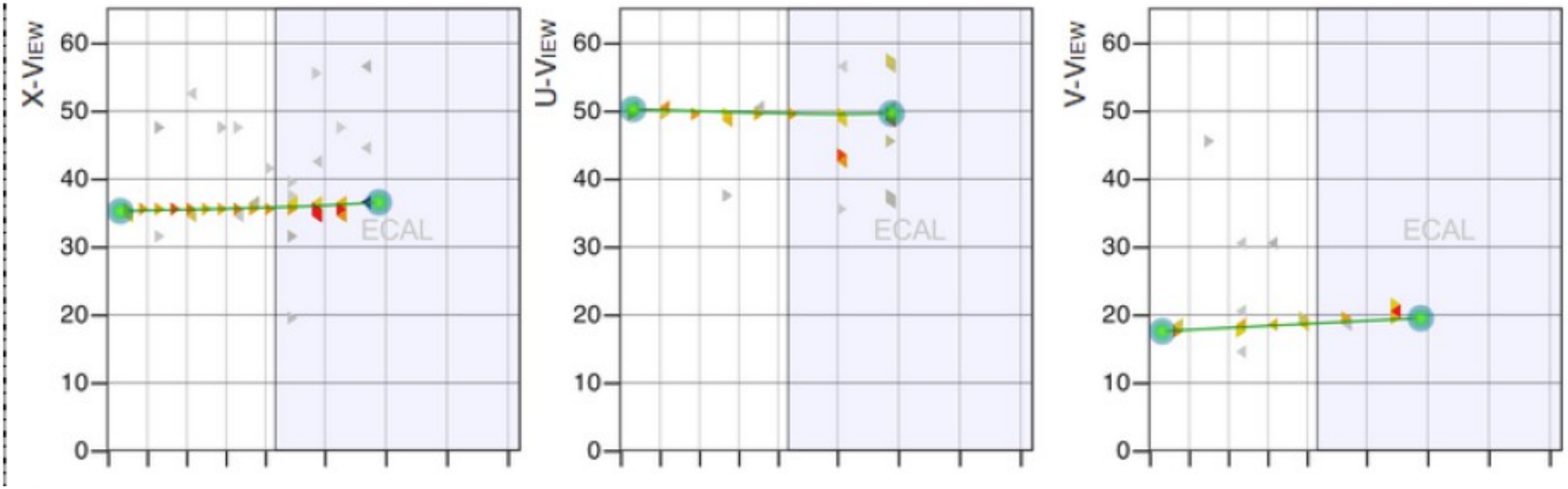
Juan Pablo looks at the double differential cross section for knockout: 220 MeV Pi+ Ta → proton + X



Pion tracking, tech preview

A. Mislivec

Pion don't range out in TB so don't use dEdX score for proton/pion PID, better for stop/interact PID
But look at data/mc scores for stopping-like pions

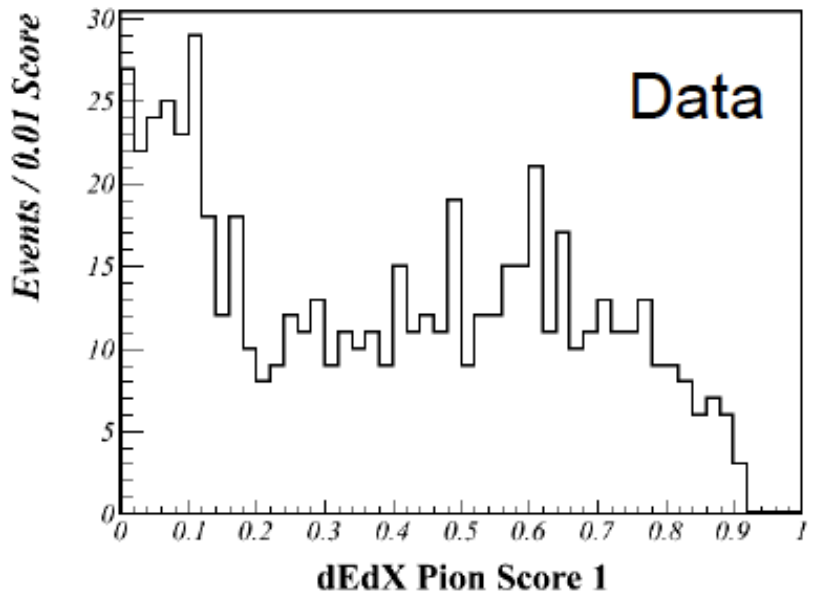


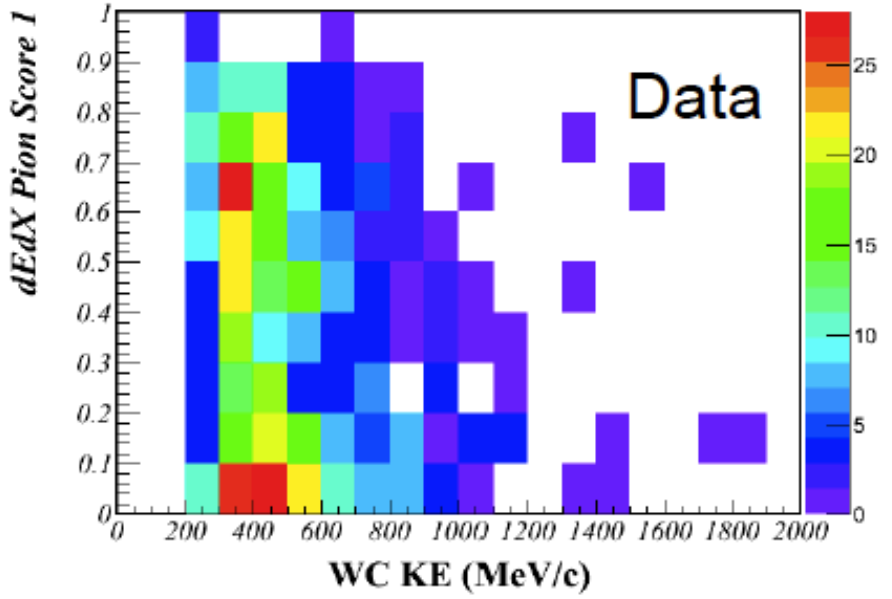
Visually, this pion was tracked to plane 29,
interacted (in Pb?), particle comes backward 5 planes
Our current reco probably sees track + one off-track cluster

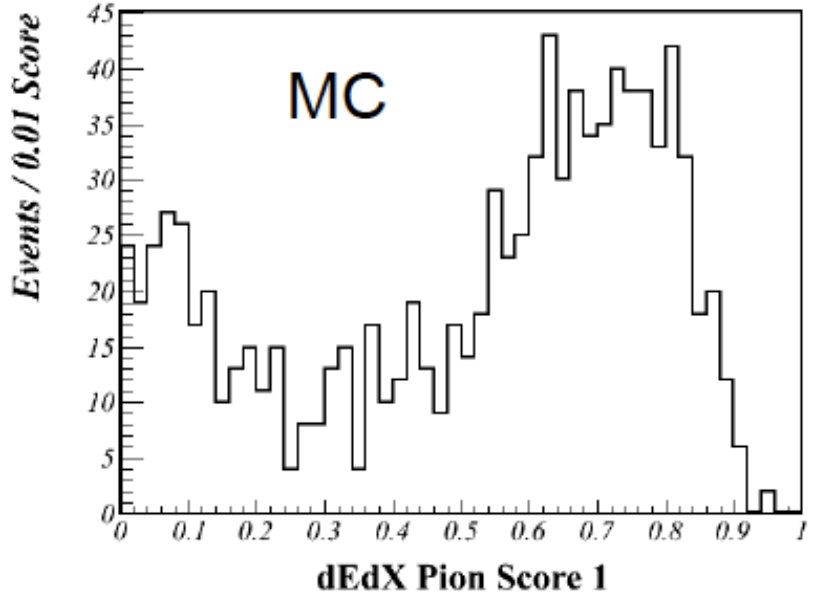
run 299, subrun 5, gate 562, slice 1
WC KE = 305 MeV, dEdX KE = 184 MeV

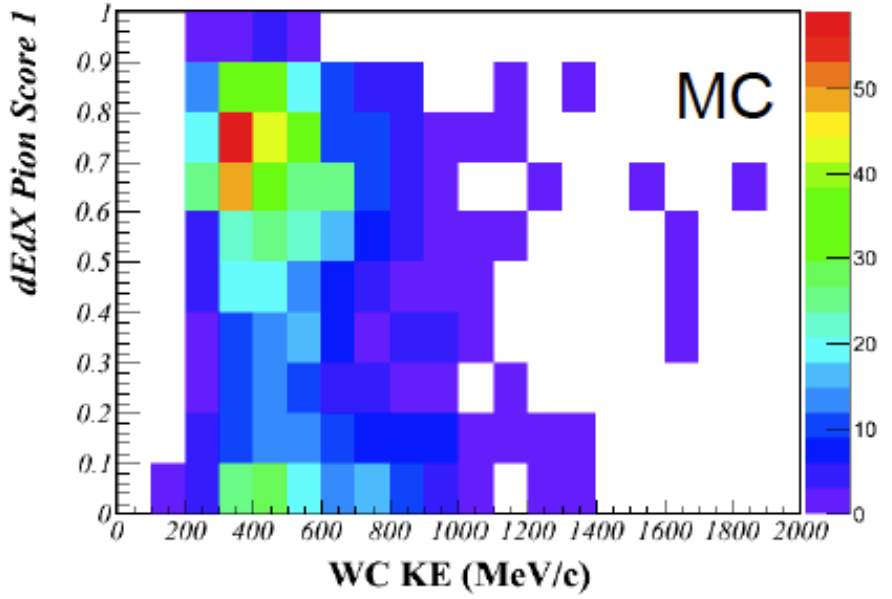
Mislivec

Pion Sample: dEdX Pion Score 1



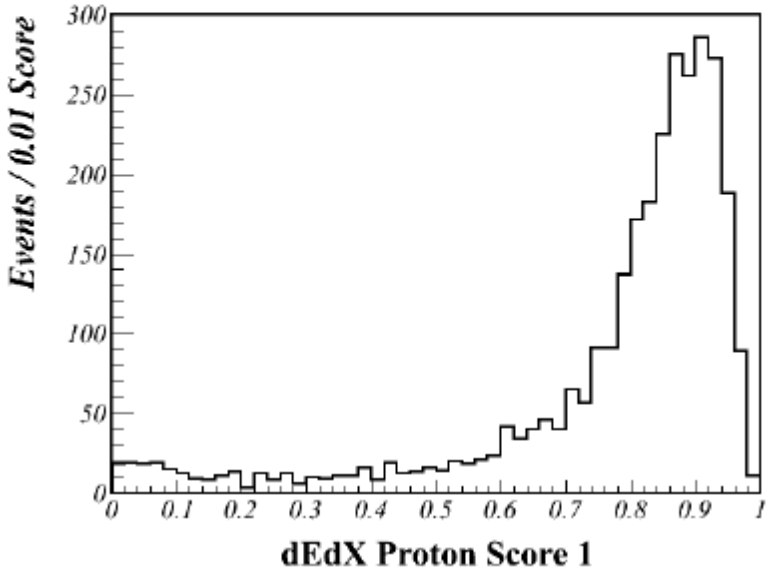


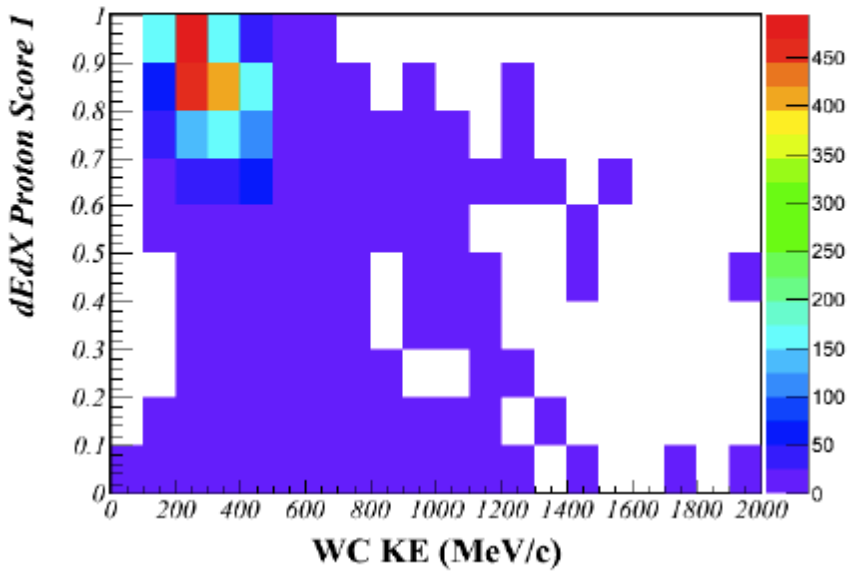


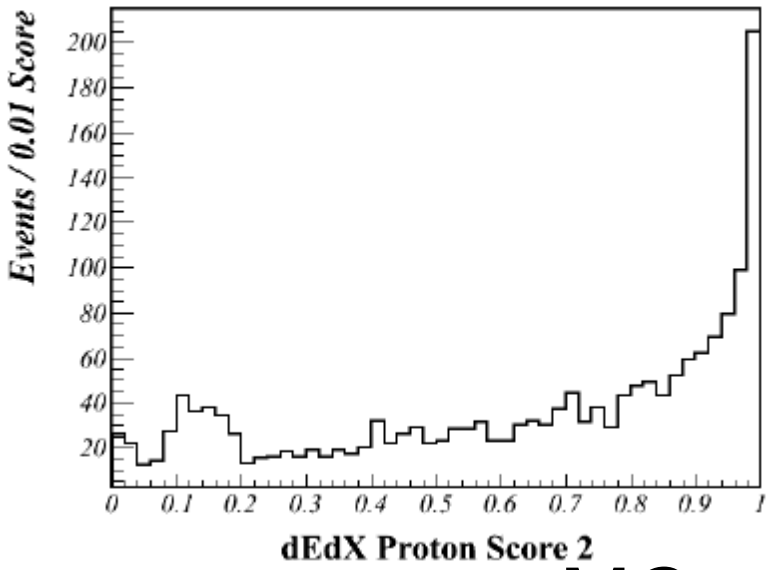


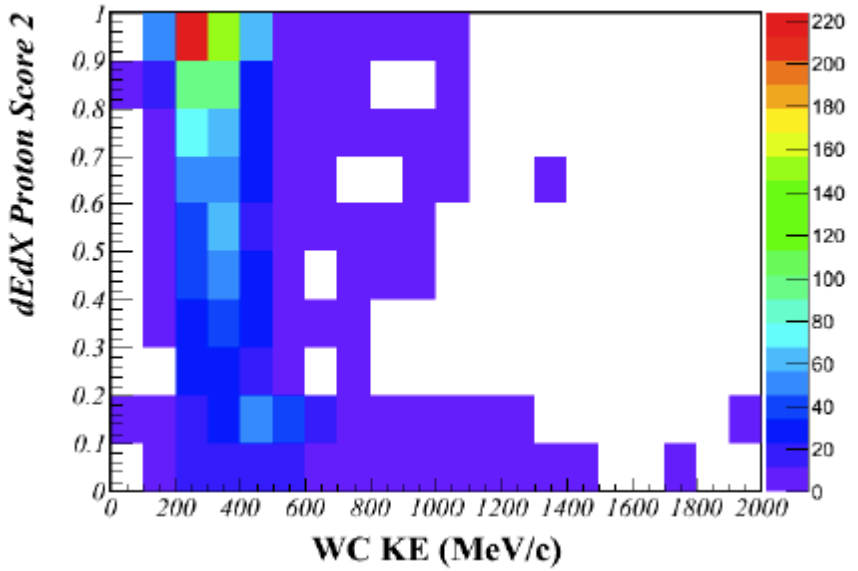
Proton tracking: mostly stopping proton data

Proton Sample: dEdX Proton Scores 1 & 2



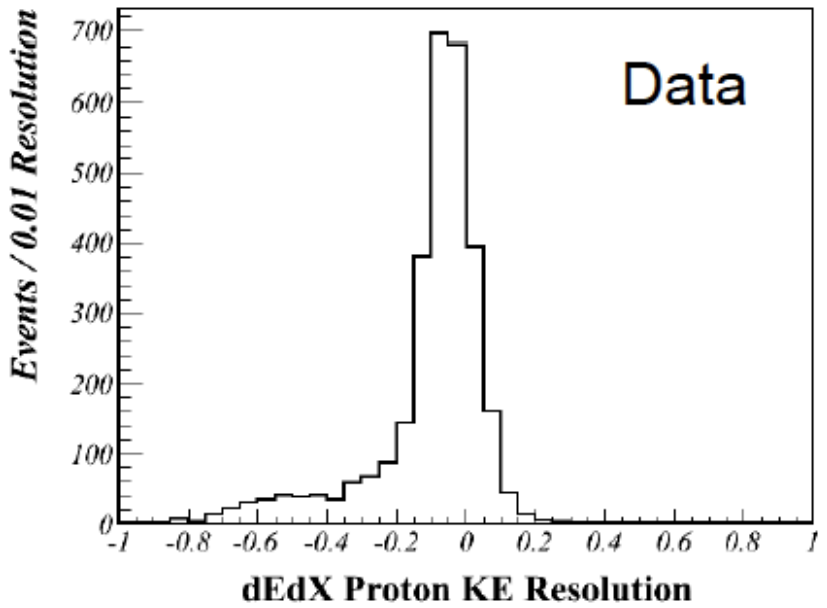


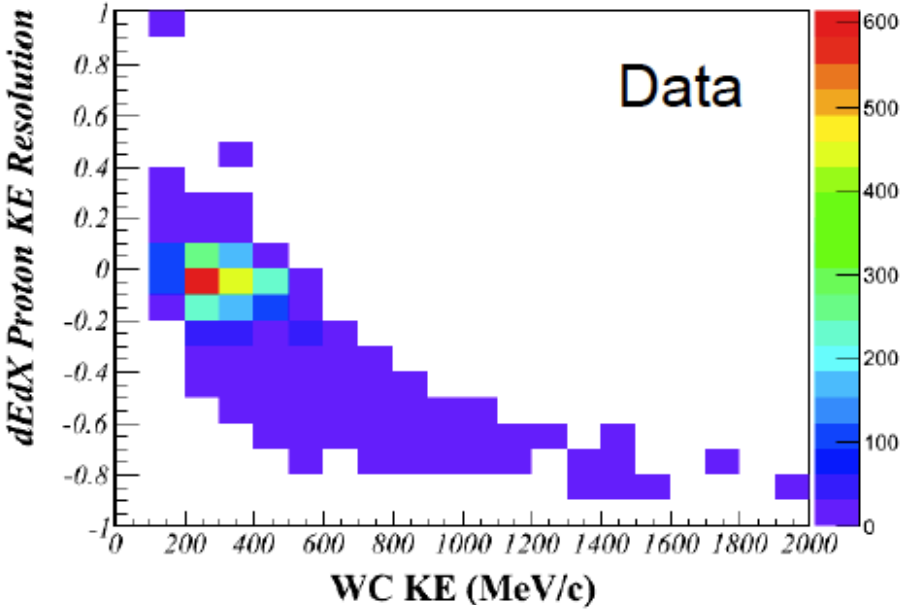




MC coming soon

Proton Sample: dEdX Proton KE Resolution





KE resolution = (dEdX_KE – WC_KE) / WC_KE

Stopping protons are ID'd well, and with reasonable energy reconstruction and a bias whose origin might be same as the one that showed up in Josh's plots

Additional test beam running?

Sketch of physics case
Sketch of effort cost
What we have what would be needed

Need to decide now? Not exactly.

But Fermilab Test Beam Facility (FTBF)
is undergoing rearrangment
how carefully do we need to keep an eye
on what changes or is obsoleted?

Scheduling at FTBF: half-year lead time
Prepping for a run: one calendar year lead time

Physics case

R&D for SiPM tubes
(but temperature control a problem)

Structure function analysis in ME beam
needs hadron shower reco energy constraint
between 2 and 5+ GeV

1 to 5 GeV electron data?

Above can be done at FTBF secondary beam
Take pion data with e.g. 8 ECAL 32 HCAL planes

Not clear we need more 0.4 to 2 GeV data
would require FTBF tertiary beam

Effort costs

To setup and run needs 6+ persons 1 month
plus tech support, plus MINERvA shifts

For design, simulation and prep
Team of four 0.5 FTE could do it, one year on clock
one leader puts in more than 0.5 FTE

Additional costs if
go to CERN instead of FTBF
revive tertiary beamline
More than 40 planes 32 HCAL planes are needed

Speed of analysis, team of four 0.5 FTE x one year

Future testbeam discussion